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ABSTRACT

This is part of a longitudinal investigation of the academic and career development of an eighth-grade class through to their third year after high school, conducted by the Grand Rapids, Michigan Public Schools/Western Michigan University - Center for Educational Studies. The study examined the relationship between science teachers' evaluations of science ability, as seen by respondents, and the resulting self-concept of science ability held by eighth-grade females (N=856). Teacher evaluations were the independent variables; self-concept of science ability was the dependent variable as measured by questionnaire items taken from the Michigan State Self-Concept of Ability Scales developed by Wilbur Brookover and his associates. The major finding noted a positive relationship between the perceived evaluations of teachers and self-concept of science ability. (Author/DS)

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SELF-CONCEPT OF SCIENCE ABILITY HELD BY EIGHTH GRADE FEMALES: SCIENCE TEACHERS AS SIGNIFICANT OTHERS

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The Midwest Sociological Society Meetings in Minneapolis, Minnesota
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This is part of a longitudinal investigation of the academic and career developments of an 8th grade class through to their third year after high school, conducted by the Grand Rapids Public Schools/ Western Michigan University - Center for Educational Studies; research project directors: Edsel L. Erickson and Donna M. Kaminski. I wish to thank the Grand Rapids Public School System for providing the data for this study; I particularly wish to acknowledge William Reaves, Director, Office of Curriculum Planning and Evaluation, Eloise Martin, Assistant to the Director, Office of Curriculum Planning and Evaluation, John Dow, Deputy Superintendent, and Cy Dubinsky, Director, Middle Schools.

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ABSTRACT

This study examined the relationship between science teachers' evaluations of science ability - as seen by respondents - and the resulting self-concept of science ability held by eighth grade females. Data were taken from the first year data of a five-year longitudinal study in progress among the eighth grade population of the Grand Rapids, Michigan public schools. Only female respondents (N=856) were utilized for this research. The questionnaire items were taken from the Michigan State Self-Concept of Ability Scales developed by Wilbur Brookover and his associates. Teacher evaluations were the independent variables; self-concept of science ability, the dependent variable. Additionally, the perceived importance attached to doing well in science on the part of teachers was used both as a control and as an intervening variable. Race and socio-economic position of respondents were also used as controls. Theoretical anchoring was in the symbolic interactionist framework which stresses the role of significant others in the socialization process and in the definition and presentation of self.

Data were analyzed with percentage tables, the Gamma measure of association and a path model. Four variations of the path model controlling for race and socio-economic position of respondents were also drawn up.

The major findings noted a positive relationship between the perceived evaluations of teachers and self-concept of science ability. While teachers were seen as attaching importance to doing well in science, many of them, on the other hand, were seen as evaluating respondents' science abilities as average. When teachers attached high importance to doing well, however, self-concept of science ability was modestly enhanced

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among respondents. Importance did not function as a meaningful intervening variable. When race and socio-economic position of respondents were controlled, teacher evaluations were salient for all groups.

Further research utilizing additional variables is needed for this age group. To reduce the disparity between male and female scientists structural and institutional changes in the society are implied.

The limited participation of women in science[1] in this country is by now well documented. A great deal of the research up to this point has focused upon the woman who is already committed to science--either as a college student or as a practicing scientist (see Rossi, 1971; White, 1975; Perucci, 1970; for example). The research discussed in this paper, however, focuses upon an earlier point in the life cycle and examines the self-concept of science ability of eighth grade females and the part played by the perceived evaluations of significant others. In other research (Fish, 1978) the role of parents, best friends, and science teachers is examined. This paper discusses only the role of teachers.

As a backdrop, recent data published by the National Academy of Sciences (1974) are illuminating. The percent of female doctoral scientists is particularly striking in several fields: engineering, 0.4%; physics and earth sciences, 2.7%. Table 1 highlights the fact that although the overall participation rates are low,

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[1]For the purposes of this paper, science refers to the following fields: engineering, computer specialties, mathematics, and the earth, life, and physical sciences. The behavioral and social sciences are excluded.

Table 1

Percent of Doctoral Scientists/Engineers Who Are Women By Field--1973

Engineering	0.4%	Mathematics	6.3%
Physics	2.7%	Social Sciences	10.9%
Earth Sciences	2.7%	Biological Sciences	11.8%
Chemistry	5.6%	Psychology	20.5%

Source: National Academy of Science, 1974.

important variations across fields occur. Females tend to be better represented in the social and behavioral sciences.

This table dramatically illustrates the under-representation of women in science. Additionally, research among engineering and science graduates of a large midwestern university noted that women careerists were less likely to be in high supervisory positions than their male counterparts. Further, their salaries were lower than males although the researcher (Perucci, 1970) points to two mitigating factors: (1) more women are in educational, academic settings than in industry where salaries are generally higher; (2) a smaller proportion of women are in engineering where salaries are usually larger than in some of the other science areas. Finally, some evidence indicates that women are more likely to gravitate to positions within science which require less investment in training and in which women exemplify in their behavior characteristics often associated with the traditional female role - obedience, conscientiousness, deference, and a preference for working with people rather than things (Helson, 1975).

A basic issue now emerging among many social scientists about the continuing under-representation of women in the sciences concerns which variables have the greatest explanatory power. Until recently, innate

differences were commonly given to explain the differential performance levels of males and females in various mathematics and science achievement and aptitude tests. Recently, attention has shifted to various socio-cultural variables. Apparently a variety of factors interact to discourage females from considering a scientific career. Some of these barriers are overt; others, covert. These include the following: (1) A socialization process in which dependence and passivity are implicitly and explicitly encouraged and in which success as measured by objective visible achievement may be perceived as antithetical to femininity (Bardwick and Douvan, 1971; Komarovsky, 1953); (2) A lower self-concept of ability among females even when they are doing well (Wylie, 1961 and 1963); (3) A higher evaluation of males by both sexes (McKee and Sherriffs, 1957 and 1959): (4) A perception of mathematics and science by females as "male domains" (Ernest, 1975; Fox, 1976; Ruina, 1973): (5) A reinforcement and perpetuation of gender-role stereotypes in the schools--teachers, books, curricular materials--(Jay and Schminke, 1975; Trecker, 1974; Howe, 1971; Good et al., 1973); and finally (6) Non-support or perception of non-support by significant others (Hawley, 1972; Bem and Bem, 1974; Kaminski, 1975 and 1978).

Up to the junior high age the importance of parental evaluations can be noted. By the eighth grade, however, perhaps the situation is changing with reference to specific areas such as science. Ordinarily, parents do not claim any particular expertise in science nor are they likely to be perceived as experts by their children. The self-contained classroom of the elementary school has been replaced in junior high by a system of specialized teachers including a science teacher.

In terms of the schools, the phrase hidden curriculum has been used by many researchers to refer to different aspects of the schooling process including the various kinds of messages about what are appropriate behavior and attitudes for males and females. A strong case can be made that girls and boys are not treated equally in the schools in terms of teacher interaction and expectations as well as in both general and subject specific (e.g., science and mathematics) texts and curricular materials.

A great deal of evidence exists to indicate that teacher expectations are a powerful factor in terms of self-concept, especially in the "mix" related to the ascribed variables of sex and/or social class. With reference to the latter variable, Rist (1973:245) notes that in many urban schools the "middle-class children are learning to control the poor, and the poor are learning to shuffle."

Frazier and Sadker (1973) refer to teachers as the "hidden carriers" of society's gender-role stereotyping; such stereotypic thinking appears to be common among both female and male teachers. Conceivably, teachers are "unconscious sexists" who are not aware of the negative outcomes of their stereotyped attitudes and behavior (Fox, 1976).

The literature points to the following: For one thing, teachers interact more frequently with boys than with girls, especially in mathematics and science classes (Review of the literature by Fox, 1976). While boys in general do receive more teacher disapproval in the lower grades (more disapproving contacts, harsh and angry tone of voice by teacher), rather than being discriminated against, boys appear to be more intense or salient stimuli for the teacher. High achieving boys seem to receive the most favorable attention as well as more intense

teacher affect and feedback. Secondly, while girls may be either ignored or rewarded for conformity and obedience, strong, consistent pressures are exerted on them to be "feminine" and good pupils. This process promotes characteristics that inhibit achievement and suppress the full development of youngsters. One consequence of these differential interaction/treatment patterns is likely to be a cumulative increase in autonomous independent behavior by boys and a lowering of self-esteem for girls as girls not only receive less attention but are criticized more for their lack of skill and knowledge (Howe, 1971; Levy, 1974; Frazier and Sadker, 1973; Sears and Feldman, 1974; Good et al., 1973).

From kindergarten on, many teachers make the assumption that girls are going to love reading and hate mathematics and science. Further, girls are not expected to think logically nor to understand scientific principles (Howe, 1971; Frazier and Sadker, 1973; Levy, 1974). Research among New York City high school teachers (cited in Levy, 1973; original source not given) indicates that while they would encourage boys to build on an interest in mathematics and science, they would--at the same time--be concerned that a girl develop competencies in areas besides those two to avoid becoming "lopsided." Additionally, both sexes accept a boy's excellence in these areas more readily than they do a girl's (Harrison, 1974).

Analyses of text and curricular materials utilized in the schools point up that these seem to reinforce traditional gender role-typing in the following ways: (1) Men and boys appear more frequently and in a greater variety of roles in which they exhibit traits which are positively evaluated by the society - e.g., independence, ingenuity, strength, and resourcefulness. Boys, in short, are "doers"; (2) Women and girls not only appear less frequently but are shown in a narrow range of stereotypical roles. Girls exhibit such "devalued" traits as dependence, fearfulness,

and passivity. They are, in short, "onlookers"; (3) Although the "new math" may have brought new mathematics concepts, a lot of the old social ones have been retained. The implicit message in texts is that science and mathematics are male preserves; females need not apply. Rarely are women scientists or mathematicians included (the very creative Emmy Noether is ignored, for example). As with the general materials, females are shown as helpless incompetents who have difficulty adding, and utilize mathematics only in dividing pies or grocery shopping. (See especially Women on Words and Images, 1974; Weitzman et al., 1972; Levy, 1974; Frazier and Sadker, 1973; Howe, 1971; Trecker, 1973; Saario et al., 1973; Jay and Schminke, 1975; Weitzman and Rizzo, 1974; Federbush, 1974; Rogers, 1975).

The purpose of this study then is to look at one salient variable--self-concept of science ability--which may conceivably inhibit females from doing well in science and/or taking science or mathematics courses later on in high school. The latter courses are crucial because they act as "critical filters" for entry into many scientific fields. (Ernest, 1975; Sells, 1974)

RESEARCH DESIGN

This study involved the eighth grade female population (N=856) of the Grand Rapids, Michigan public school system in 1976-77. A questionnaire was administered to all eighth graders (N=1721) as the first year of a five year longitudinal study examining a host of variables. The questionnaire was based on items and scales developed by Wilbur Brookover and his associates (1962, 1965, 1967) at Michigan State University.

Questions pertaining to the self-concept of science ability, the perceived evaluations of science ability on the part of parents, science

teachers, and best friends, and the perceived importance attached to doing well in science on the part of these same significant others were used by the researcher out of the larger questionnaire. (Perceived evaluation and perceived importance will henceforth be referred to as evaluation and importance.) Evaluations were the independent variables; self-concept of science ability, the dependent variable. The latter was measured by two items from an eight-item self-concept of science ability scale designed by Brookover and associates (1962, 1965, 1967). Researchers have noted a high degree of consistency among items when items have been taken out of the complete scale (Throckmorton, 1975). Additionally, importance was used both as a control using Gamma and as an intervening variable in the path model. Seven hypotheses and three sub-hypotheses were drawn up to test the relationships between the independent and the dependent variables.

The theoretical orientation used was the symbolic interaction framework within the Meadian tradition as amplified and extended upon by John Kinch (1963) and more especially, Wilbur Brookover and his associates; the latter have contributed theoretical insights and empirical data regarding the "self-concept of ability" construct. The symbolic interaction perspective stresses the importance of those defined as significant others, and the role their actual and perceived evaluations and expectations play in how a person comes to perceive self. Self is viewed as process, not structure. Both Mead (1934) and Blumer (1969) stressed the salience of the meanings that are attached to the actions and evaluations of others (especially significant others in the person's social world). Females, for example, in organizing their own behavior take into account the meanings attributed to that behavior (verbal and otherwise)

as well as their perceptions of the way others view them. If females feel parents or teachers see them as "not very bright" in science; or if peers are seen as viewing science as an "unfeminine" interest, this has important implications for that young female's self-concept of science ability. Conceivably, this could lead to not doing well in science or not taking science courses.

The data were analyzed bv the use of percentage tables, the Gamma measure of association, and a path model. Four variations of the path model controlling for race and socio-economic position of respondents were also utilized. Respondents were dichotomized into white or minority for the racial category (84% of the minority youngsters were black, with a small representation among Hispanic, Native American, Oriental, and other).

Additionally, the Duncan occupational scale (Reiss et al., 1961) was used for the socio-economic variable. To dichotomize, the choice of cut-off points was based upon the percent of respondents in the range of occupations. An attempt was made to use cut-off points that reflected a division of the population into halves. Thus, the Duncan Scale values ranging from 02-23 included approximately one-half (48%) of the respondents, and those ranging from 24-96 included 52% of the respondents. Therefore, respondents whose parental occupations fell within the 02-23 range were categorized as of low socio-economic position; those whose parental occupations fell within the 24-96 range were categorized as of high socio-economic position. It is apparent that the high socio-economic category encompassed a wide range of occupations. This is a reflection of two factors: (1) Grand Rapids is generally considered a "working class" city and (2) many middle and upper-middle class youngsters

attend the Christian Reformed School, and thus are "siphoned off" from the public school route.

FINDINGS

Two percentage tables are discussed, as well as the Gammas and the path weights.

Table 2 presents the frequency distribution of responses for science teachers on the evaluation variable. The following can be highlighted: (1) Respondents most frequently (48%) see their teachers as rating them about the same as other eighth grade students with reference to work they can do in science;(2) Nearly two-fifths see teachers as rating them better than other eighth graders;(3) Few teachers are perceived as rating respondents either as "among the best" or, more especially, as "among the poorest."

Table 3 presents the frequency distribution of responses for science teachers on the importance variable. The following can be noted: (1) 80% of the respondents see their teachers as considering doing well in science as important or very important; (2) Only a few (4%) feel that it doesn't matter at all to the teacher how the respondent does in science.

The distribution of responses on the evaluation variable (Table 2) and on the importance variable (Table 3) highlights a difference. While less than half of the teachers are seen as evaluating respondents' science abilities highly, a large percent are seen as attaching high importance to doing well in science.

Table 2

Teachers' Evaluations of Science Ability As Seen By Eighth Grade Female Respondents

Evaluation	Teachers	
	N	%
Among the Best	86	10
Better Than Other 8th Grade Students	325	38
The Same as Other 8th Grade Students	411	48
Poorer or Among the Poorest	34	4
TOTAL	856	100.0

Table 3

Importance Attached by Science Teachers to Doing Well in Science as Seen by Eighth Grade Female Respondents

Importance	Teachers	
	N	%
Very Important	229	27
Important	462	54
Not Too Important	133	16
It Doesn't Matter At All	32	4
TOTAL	856	100.0

Additionally, the Gamma measure of association was used to test the bivariate relationship between teacher evaluations and self-concept of science ability. As can be seen from Table 4, the relationship is a positive (direct) one with a linear pattern. The Gamma of +.56 indicates a relationship of substantial strength (Davis, 1971). The distribution of responses thus is in the expected direction, ranging from 47% in the low self-concept, low teacher evaluation cell to 41% in the high self-concept, high teacher evaluation cell, and lends support to the salience of teacher evaluations in a young female's perception of self in the realm of science. When teachers are seen as evaluating these youngsters as "among the best," nearly 80% of the respondents place themselves in the two highest categories of the self-concept scale. Conversely, when teachers are seen as evaluating respondents as "poorer" or "among the poorest," just over three-fourths of the respondents place themselves in the two lowest categories of the self-concept scale. It is also of interest to note that the incongruent cells (low, high or high, low) contain no cases.

Findings from the path analyses in which multivariate relationships were examined were consistent with the findings which examined bivariate relationships. Overall, the teacher evaluation paths were stronger than were the parental or friend paths. The parental paths were the weakest of the three sets. The teacher paths are reproduced in Table 5.

Table 4

Cross-Tabulation Between Self-Concept Scores and Perceived Teacher Evaluations

Self-Concept Scores	Teacher Evaluations									
	Poorer Or Among The Poorest		The Same as Others		Better Than Most		Among The Best		Total	
	N	%	N	%	N	%	N	%	N	%
High 10 "Among the Best"; "Mostly A's"	0	0	2	1	10	3	35	41	47	6
9 Combination of Items from 10 & 8	1	3	43	10	90	28	32	37	166	19
8 "Better Than Most"; "Mostly B's"	3	9	114	28	102	30	11	13	230	27
7 Combination of Items 8 & 6	4	12	185	45	86	27	7	8	282	33
6 "Average"; "Mostly C's"	10	29	50	12	25	8	1	1	86	10
5-2 "Below Average" or "Among the Poorest"; "Mostly D's & E's"	16	47	17	4	12	4	0	0	45	5
TOTAL	34	100.0	411	100.0	325	100.0	86	100.0	856	100.0

Gamma = +.56

Table 5

Teacher Evaluation Paths, All Path Variations

Paths	Female Respondents				
	All Respondents	White Females, Low SES	White Females, High SES	Minority Females, Low SES	Minority Females, High SES
	N = 856	N = 209	N = 349	N = 203	N = 95
Teacher Evaluation ⟶ Self-Concept	.3043	.2753	.3117	.2721	.3050

While there is a similarity between all of the path weights, those for white and minority females of high socio-economic position are especially similar to each other and to the path weight for all eighth grade females. Although the teacher paths are the strongest of the three sets of significant others, the size of the path weights indicates that many other variables are involved also.

Finally, when the importance variable was dichotomized into high and low importance on the part of teachers, self-concept of ability was modestly enhanced (The difference between the Gammas was +.07). No support was found for importance as an intervening variable between evaluations and self-concept.

DISCUSSION

Overall, the relationship of science teachers' evaluations to the self-concept of science ability among eighth grade females has been highlighted and supports the assumption made in the symbolic interaction framework that the evaluations--perceived or actual--of significant others do play an important role in the self-evaluation process. The fact that

many of these youngsters see their teachers as evaluating them as having average science abilities but feel that teachers attach high importance to doing well may simply reflect a general emphasis upon grades per se. In other words, this may not be unique with reference to the area of science but may hold for other academic areas as well.

As noted, in subject-specific areas such as science it is possible that teachers become particularly relevant during the junior high years. Since science teachers may be perceived as experts, it is possible that they do the initial labeling and defining of the youngster. Parents, in turn, may take these assessments by the teacher as their own. If the science teacher, for example, proclaims to parents that "Beth isn't very good in science," this assessment may be internalized by the parents themselves without any questioning. Beth may ultimately have a very negative conception of her own science ability, and possibly, about science generally.

In related literature Fox (1976) notes that not only do high school teachers appear to hold different expectations for males and females in mathematics, but precocious female students may be perceived in a negative and even hostile fashion by these teachers. It is also possible to point to very fragmentary evidence (Anderson, 1963) noting that students who have an "inspirational" teacher tend to rate themselves higher in mathematics and science.

It should be re-emphasized that in this study when teachers are seen as evaluating respondents in a highly positive way ("among the best"), none of the respondents see themselves as "below average" or "among the poorest" in comparison with other eighth grade students. Conversely, when teachers are seen as evaluating respondents in a very negative way

("poorer" or "among the poorest") none of the respondents see themselves as "among the best."

The fact that all of these youngsters regardless of racial and socio-economic category perceive teacher evaluations as meaningful underscores the potential role that science teachers might play in terms of encouraging young females to take science courses or even consider a career in a science field. While there is no necessary relationship between self-concept of science ability and interest in a science career (this awaits further research), two research efforts bearing on this point merit comment. Kaminski (1978) found that for both male and female high school students a significantly greater proportion of the high self-concept than the above average self-concept students selected an advanced science course in high school. While taking an advanced science course does not necessarily lead to preparing for a scientific career, provocative questions that bear further research are raised. Likewise Erlick and LeBold (1975) found that for those high school students of both sexes who were even considering science or mathematics careers, all reported above average assessments of themselves on mathematics, mechanical, problem solving, and science ability. Perhaps not surprisingly, both Kaminski and Erlick and LeBold found more males than females rating themselves high in science ability.

While research is forthcoming, at this point in time little data is available on this age group of youngsters for self-concept with reference to science and mathematics skills or abilities. The following additional variables with reference to the educational system might be germane: sex and race/ethnic membership of teacher, school climate, role of school counselors, expectations of teachers. Actual interviews with

teachers would provide additional insights as would grades of students in science courses and perhaps interest in a career in a scientific field. If teachers are in fact "unconscious sexists" who perpetuate and reinforce traditional gender role stereotypes, many structural and institutional changes are needed and implied before the percentage differential between male and female scientists is reduced.

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